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THE INFLUENCE OF THE PROJECT-BASED LEARNING MODEL ON STUDENT LEARNING OUTCOMES ON THE ACID-BASE CONCEPT (A Case study at Senior High School No. 2 Medan)Prihatni Yoshepine Bangun^{**}, Eddiyanto^a, Sitti Darna Munthe^a^aDepartment of Chemistry, Universitas Negeri Medan, Medan, Indonesia, 20221**Abstract**

The research aims to determine the effect of the project-based learning model on learning outcomes and students' responses to acid-base material. Based on observations and interviews with students and teachers, the background of this study is that chemistry education remains teacher-centered and lacks practical activities, partly due to the COVID-19 pandemic. Hopefully, this model will engage students more actively in learning and improve their learning outcomes. This experimental research employs a pretest-posttest control group design. The research samples were students from class XI IPA 2, who experienced the project-based learning model (experimental class), and class XI IPA 1, who followed the conventional model (control class). The instruments used in this study were tests to measure student learning outcomes and questionnaires to assess student responses to the implemented learning model. The normality test results showed a significant value of 7 for the experimental and control classes at an alpha level of 0.05. The homogeneity test indicated a value of 1.08 at an alpha level of 0.05, suggesting the data are typically distributed and have homogeneous variance. The results of the right-sided t-test showed a significant value of 7.35, which is greater than the critical value of 1.669, indicating that t_{count} is greater than t_{table} , leading to the rejection of the null hypothesis (H_0) and the acceptance of the alternative hypothesis (H_a).

Keywords: Project-based learning, learning outcomes, acid-base reactions, student responses

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INTRODUCTION

Chemistry is one of the Natural Science subjects taught in high school that requires theoretical learning and practical activities such as experiments to help students develop fundamental skills and a deeper understanding of the material. This branch of science also encourages students to connect the material to real-world phenomena. Many students find chemistry challenging and do not enjoy the lessons. [1]

Results from observations and interviews with chemistry teachers at SMA Negeri 2 Medan on October 18, 2022, indicate that the school is still implementing the 2013 curriculum. Despite this, classroom learning primarily relies on conventional methods such as lectures, discussions, and assignments. Moreover, chemistry lessons, especially for grades X and XI during the 2022/2023 academic year, have not included practicums or projects because the school laboratory is renovating, preventing any practical activities. During online learning, teachers recommended that students watch video links shared in the class WhatsApp group for material related to practicums.

Interviews with several grade X and XI students at SMA Negeri 2 Medan revealed that their learning activities have never included practicums or projects related to applying chemistry lessons to real-world products. The students find chemistry difficult, abstract, and tedious. Learning activities still rely on lectures, discussions, and assignments, primarily through Student Worksheets (LKS). Due to the school's recent

return to face-to-face learning after a year of disruptions caused by the COVID-19 pandemic, many students are disinterested and do not understand chemistry lessons. The students preferred learning chemistry through projects, especially those involving product creation, as it helps them see chemistry as tangible and less abstract.

Due to limited resources and the government's emphasis on hand hygiene to prevent COVID-19, researchers are undertaking a project to create solid soap suitable for use on the entire body. This project builds on previous research involving dragon fruit peels [2]. This initiative aims to highlight the practical benefits of chemistry by creating original soap products for personal use, sold by entrepreneurs, or given as souvenirs. It builds upon previous efforts demonstrating how understanding, creativity, and entrepreneurial spirit intersect with chemical materials, mainly through processes like saponification, to create valuable products for everyday life [3].

Regarding the upcoming project, the suitable chemical material chosen is acid-base concepts studied in class XI. According to students, mastering this material involves understanding the concepts deeply, not just memorizing theory [4]. Information gathered also revealed that students' cognitive abilities in chemistry remain low, as evidenced by the Mid Semester Examination results for grade XI IPA, where many students scored below the minimum passing grade (KKM). The KKM score for Chemistry is 75; less

than 50% of students met this benchmark. Observations and interviews at the school indicate that implementing a project-based learning model would be suitable for assessing student learning outcomes at SMA Negeri 2 Medan.

Project-Based Learning (PjBL) is an educational approach where students solve problems, plan projects, and create tangible products [5]. This method encourages student collaboration to produce practical and valuable outcomes [6]. According to Syahril (2019) [7], the benefits of PjBL include providing authentic experiences that enhance student understanding and enjoyment through active participation in real-world project design.

Previous studies, such as Maula (2014) [8], have shown that implementing PjBL can significantly improve creative thinking skills and academic performance. The experimental group in Maula's research demonstrated higher scores in creative thinking (86.17) and cognitive learning outcomes (84.67) compared to the control group (70.25 and 65.44, respectively). Meriliani (2019) [9] also found that student groups using PjBL outperformed traditional methods.

Further support comes from Siburian (2021) [10], whose research indicated a 22.23% increase in student achievement in a PjBL environment, highlighting improved learning completeness across multiple assessment cycles.

Given these findings, the researchers aim to enhance student learning outcomes and inspire and motivate students by equipping them with practical skills in product development. Despite extensive research on PjBL, its application, specifically at Senior High School No. 2 Medan, has not been thoroughly explored. This gap motivated the researchers to initiate a study titled "The Influence of The Project-Based Learning Model on Student Learning Outcomes of Class XI on Acid-Base Material at SMA Negeri 2 Medan".

METHOD

The research will occur at SMA Negeri 2 Medan, on Jalan Karang Sari, No. 435, Sari Rejo, Medan Polonia District, Medan City, from October 2022 to March 2023. The study employs experimental research to examine one variable's influence on another [11]. A quantitative method was utilized, as recommended by [12], wherein data are presented numerically, measured using statistical analysis, and directly related to the research problem to conclude.

The population for this study consists of all grade XI IPA students at SMA Negeri 2 Medan during the 2022/2023 academic year, totaling nine classes. Using purposive sampling, two classes were selected: class XI IPA 1 (Control Class) and class XI IPA 2 (Experimental Class). Class XI IPA 2 will implement the project-based learning model, while the control class taught by a

conventional teaching approach. Purposive sampling was chosen for its suitability in quantitative research, allowing for selection criteria that align with the research objectives.

Research Variables

Three variables in this study include:

1. There are two independent variables (X) in this study, namely:
(X1): project-based learning model
(X2): conventional learning model
2. The dependent variable (Y) is student learning outcomes.
3. The control variable (Z) is acid-base material, books used, instruments, and research time.

Research Design

We employed a Pretest-Posttest Control Group Design, which involved selecting two sample classes from the population and assigning them as the experimental and control groups. Before beginning the research, the dependent variable (student learning outcomes) was measured to ensure the samples were relatively homogeneous. Changes in scores were then measured after the completion of the study. Different treatments were applied to the experimental and control groups, and their respective learning outcomes were observed and measured [13].

In grade XI IPA, a pretest was administered to both classes. The experimental class received the project-based learning model, while the control class did not. Due to inadequate school conditions, such as ongoing renovations, projects were conducted at home. After the learning activities, a posttest was administered to both classes to evaluate differences in learning outcomes. The pretest and posttest consisted of multiple-choice questions conducted in class under controlled conditions with predetermined timing. The researchers collected the responses. Following the posttest, a student response questionnaire was distributed to gauge students' reactions to the implemented learning model.

Table 1. Research design Pretest-Posttest Control

Group	Group Design		
	Pretest	Treatment	Posttest
Experiment	Y1	X1	Y2
Control	Y1	X2	Y2

Where:

Y1 : experimental class pretest

Y1 : pretest control class

Y2 : posttest experimental class

Y2 : posttest control class

X1 : application of the project-based learning model

X2 : application of the conventional model

Research Instruments

This research measures student learning outcomes and student responses, so in this study, the test instrument and the non-test instrument were employed.

Test Instruments

We employed a multiple-choice test consisting of 40 questions, which were validated before use. This test instrument was designed to assess student learning outcomes in Acid-Base material using a project-based learning model in grade XI IPA at SMA Negeri 2 Medan. The test was administered twice: once as a pretest and once as a posttest. Before administering the test to students, the researcher validated the instrument by evaluating several components. These included:

- Validity: Ensuring the test accurately measures the intended learning outcomes.
- Reliability: Consistency and stability of the test results over repeated administrations.
- Item Difficulty Level: Analyzing how challenging or easy each question is for students.
- Constructors: Checking if the test adequately covers the content and skills being assessed.
- Differential Power Tests: Assessing if the test can differentiate between levels of student knowledge and skills effectively.

These steps were crucial to ensure the test was fair, reliable, and aligned with the research objectives.

Non-test Instruments

In addition to the multiple-choice test, we utilized a non-test instrument in the form of a questionnaire. This questionnaire employed a Likert scale and was administered to the experimental class to gather feedback on their learning experiences with the applied project-based learning model [14-16]. The Likert scale is designed to measure opinions, attitudes, or perceptions of individuals or groups regarding a specific topic. It offers a range of response options from strongly agree to disagree strongly, allowing students to express their views with varying degrees of agreement or disagreement. This data was subsequently analyzed to assess student responses and perceptions towards the implemented learning model. [13]

Data Analysis

In this study, data analysis commenced with several key steps:

- Normality Test: This test assessed whether the data followed a normal distribution. Normality is important for specific statistical tests to be valid.
- Hypothesis Testing: Hypothesis testing was performed to determine the significance of any observed differences between the experimental

group (using the project-based learning model) and the control group (using conventional methods). This typically involves comparing means or proportions to conclude about the effectiveness of the project-based learning model on student outcomes.

- Student Response Analysis: Responses from the Likert scale questionnaire were analyzed to understand how students perceived and responded to the project-based learning approach. This analysis helps gauge student satisfaction, engagement, and overall perceptions of the learning model.

Each of these analyses contributes to evaluating the effectiveness of the project-based learning model on student learning outcomes and understanding student perspectives on the learning experience.

RESULTS AND DISCUSSION

The research was carried out at SMA Negeri 2 Medan, utilizing two classes as samples. The experimental class implemented the project-based learning model, while the control class followed the conventional teaching model. Initially, the researcher administered a pretest to assess the baseline abilities of students from both classes. Subsequently, the researcher employed distinct instructional approaches tailored to each group.

Table 2. Students' pretest and posttest scores

Group	Pretest	Posttest
Experiment	52.6±2.1	86.88±2.3
Control	52.2±1.8	76.44±2.2

Based on the analysis of the pretest and posttest results from the two sample classes at SMA Negeri 2 Medan, the following findings were observed:

Pretest Results

The average score in the experimental class (using the project-based learning model) was 52.66, while in the control class (using the conventional model), it was 52.22. This indicates that the basic abilities of both sample classes were initially similar.

Posttest Results

After implementing the project-based learning model, the average posttest score in the experimental class significantly increased to 86.88. In contrast, the control class, which used the conventional teaching approach, had an average posttest score of 76.44. This demonstrates that students in the experimental class achieved higher learning outcomes compared to those in the control class.

Hypothesis Testing

A t-test was conducted to test the hypothesis. The t-count value obtained was 7.35, and the critical t-table value at a significance level of 0.05 was 1.669. Since $t\text{-count} > t\text{-table}$, the null hypothesis (H_0) was rejected, and the alternative hypothesis (H_a) was accepted. This indicates that there is a significant difference in the average learning outcomes between students taught using the project-based learning model and those taught using the conventional model at SMA Negeri 2 Medan, specifically in understanding the acid and base concept in class XI.

These findings emphasize the effectiveness of the project-based learning model in enhancing student learning outcomes compared to traditional teaching methods, where students are more actively engaged and independent in their learning process [17-20].

The research also revealed highly positive responses from students, including increased curiosity, enthusiasm, and motivation to learn, particularly in chemistry. These responses were gleaned from the analysis of questionnaire data administered to the experimental class. Students' active engagement in learning activities was notably influenced by these positive perceptions [21].

In contrast, conventional teacher-centered learning, characterized by passive student roles and reliance on lectures and Q&A sessions, did not foster the same level of student activity and engagement as observed in the project-based learning model [22-24]. Despite the researcher's efforts to control the class and facilitate interactions through questions and answers, the student's level of involvement and motivation remained higher in the project-based learning environment.

These findings highlight the significant impact of active, student-centered learning approaches like project-based learning in promoting enthusiasm and deeper engagement among students, especially in subjects like chemistry [25].

Despite facing challenges such as the inability to conduct projects at school due to ongoing renovations, which necessitated conducting the projects at students' homes in groups and encountering time constraints and less conducive classroom environments, the research conducted at SMA Negeri 2 Medan concluded that the project-based learning model yielded superior results compared to the conventional model. This conclusion was drawn based on improved student learning outcomes and positive responses observed during learning activities.

These findings suggest that the project-based learning model is feasible and should be implemented, especially in teaching chemistry. Doing so can effectively facilitate the achievement of learning objectives, enhance student enthusiasm for the subject matter, and encourage deeper engagement in learning activities. Despite the logistical challenges faced during

this research, the benefits of implementing innovative teaching methods like project-based learning are demonstrated in enhancing overall educational outcomes and student satisfaction [26].

CONCLUSION

To conclude, the average learning outcomes of students taught using the project-based learning model are significantly higher than those taught with conventional models on acid-base materials at SMA Negeri 2 Medan. This conclusion is supported by the statistical analysis where the t-count (7.35) exceeds the critical t-table value (1.669) at a significance level of 0.05. Therefore, the null hypothesis (H_0) is rejected, and the alternative hypothesis (H_a) is accepted.

Student responses regarding applying the project-based learning model in the experimental class for acid-base material at SMA Negeri 2 Medan were overwhelmingly positive, with 88.33% overall satisfaction. Specifically, 64.02% of students strongly agreed, 33.05% agreed, 1.52% disagreed, and 0% strongly disagreed with the effectiveness of the project-based learning approach.

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